EXHIBIT L

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

APPLE INC.,
Petitioner,

v.

COREPHOTONICS, LTD.,
Patent Owner.

Case No. IPR2020-00905
Case No. IPR2020-00906
U.S. Patent No. 10,225,479

DECLARATION OF JOHN C. HART, Ph.D. PURSUANT TO 37 C.F.R. § 1.68

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I. BACKGROUND

1. I have been retained as a technical expert by Patent Owner Corephotonics Ltd. ("Patent Owner" or "Corephotonics") in this proceeding. Corephotonics has asked me to provide my expert opinions concerning certain technical aspects of imaging system design as they relate to the Petitioner Apple Inc.'s petition for inter partes review of U.S. Patent 10,225,479 ("'479 patent") in Case Nos. IPR2020-00905 ("-00905 IPR") IPR2020-00906 ("-00906 IPR") and the accompanying Declarations of Fredo Durand. In particular, I have been asked to respond to Dr. Durand's opinions set forth in his declarations, Ex. 1003 in each IPR.

2. The statements in this declaration summarize my opinions on these matters based on my over 30 years of study and research of imaging systems, my education, knowledge, skills, and my review and analysis of the materials referenced herein.

3. I am being compensated for my work in this matter at the rate of $575 per hour. I am also being reimbursed for reasonable and customary expenses associated with my work and testimony in this investigation. My compensation is not contingent on the outcome of this matter or the substance of my testimony

II. SUMMARY OF OPINIONS

4. In the preparation of this declaration, I have reviewed:

- The '479 patent (Ex. 1001)[1]
- Prosecution history of the '479 patent (Ex. 1002)
- The declarations of Dr. Fredo Durand (Ex. 1003 in each IPR)
- The curriculum vitae of Dr. Fredo Durand (Ex. 1004)
- U.S. Patent No. 7,859,588 ("Parulski") (Ex. 1005)
- English translation of Japanese Patent Application Publication No. 2007-259108 ("Soga") (Ex. 1006)
- Jacobs et al., "Focal Stack Compositing for Depth of Field Control," Stanford Computer Graphics Laboratory Technical Report 2012-1 (Ex. 1007)
- Prosecution history of the Morgan-Mar patent (Ex. 1008)
- U.S. Patent No. 8,989,517 ("Morgan-Mar) (Ex. 1009, Ex. 2037)
- PCT Publication No. WO2013140359 ("Shalon") (Ex. 1010)
- U.S. Patent Application Publication No. 2008/0030592 ("Border") (Ex. 1011)

[1] Where a given Apple exhibit appears with the same exhibit number in both IPRs on the '479 patent, or a given exhibit number is used in only one of the IPRs, I refer to the exhibit by that number. Where the same exhibit number is used for different exhibits in the two IPRs, e.g., for Dr. Durand's declarations, I will attempt to always clarify which IPR's exhibit I am referring to.

- English translation of Japanese Patent Application Publication JPS5862609 (“Kawamura”) (Ex. 1012)
- Richard Szeliski, Computer Vision—Algorithms and Applications (2011) (“Szeliski”) (Ex. 1013)
- U.S. Patent No. 6,259,863 (“Maruyama”) (Ex. 1014)
- English translation of JP Pub. No. 2013-106289 (“Konno”) (Ex. 1015)
- Ralph E. Jacobson et al., The Manual of Photography: photographic and digital imaging, 9th Edition, 2000 (“Jacobson”) (Ex. 1016)
- U.S. Patent App. Pub. No. 2010/0321511 (“Koskinen”) (Ex. 1017)
- U.S. Patent No. 7,206,136 (“Labaziewicz”) (Ex. 1018)
- Milton Katz, Introduction to Geometrical Optics (2002) (“Katz”) (Ex. 1019)
- Warren J. Smith, Modern Lens Design (1992) (“Smith”) (Ex. 1020)
- The declaration of Dr. José Sasián (Ex. 1021)
- U.S. Patent No. 8,908,041 (“Stein”) (Ex. 1023)
- U.S. Patent No. 8,406,569 (“Segall”) (Ex. 1024)
- U.S. Patent No. 8,824,833 (“Dagher”) (Ex. 1025)
- U.S. Patent No. 5,546,236 (“Ogata”) (Ex. 1026)
- File History for Provisional No. 61/752,515 to Stein (“Stein provisional”) (Ex. 1027)
- Bae et al., “Defocus Magnification,” Eurographics 2007 (“Bae”) (Ex. 1028)

- Specification sheet for Sony ICX629 image sensor ("ICX629") (Ex. 1029)
- Specification sheet for Sony ICX624 image sensor ("ICX624") (Ex. 1030)
- Product manual for Kodak Easyshare V610 (Ex. 1033)
- U.S. Patent No. 7,112,774 ("Baer") (Ex. 1034)
- Robert E. Fischer et al., Optical System Design (2008) (Ex. 1035)
- The declaration of Dr. Duncan Moore (Ex. 2015)
- The transcript of the 26 Jan. 2021 deposition of Dr. Fredo Durand. (Ex. 2036)
- Forsyth and Ponce, "Computer Vision: A Modern Approach" (1st ed.) (2003) (Ex. 2038)
- The declaration of Eli Saber filed for IPR2020-0860.
- District court filings, emails, and agreements concerning Apple's evaluation of Corephotonics' technology relevant to secondary considerations (Exs. 2004–2012, 2018–2023)
- The declaration of Eran Kali (Ex. 2013)

5. In forming the opinions set forth herein, I have considered:

a. The documents listed above;

b. My education, knowledge, skills, and experience in the design and development of imaging systems; and

c. The level of skill of a person having ordinary skill in the art (POSITA) at the time of the effective filing dates of the ’479 patent.

6. As I explain in further detail below, it is my professional and expert opinion that Apple and Dr. Durand have failed to demonstrate that any of the challenged claims of the ’479 patent were obvious, under any of the grounds or combinations of references that Apple has raised in these two IPRs.

III. EDUCATIONAL AND EMPLOYMENT BACKGROUND

7. As indicated in my Curriculum Vitae, attached as Exhibit 2003, I am a tenured full Professor of Computer Science in the Department of Computer Science at the University of Illinois at Urbana-Champaign. As an educator for the past three decades, I have taught courses in computer graphics and related areas to thousands of students. I also strive to provide opportunities for the general public to learn more about computing. For example, in 1999 I oversaw the production of the documentary “The Story of Computer Graphics.” I also teach an open course on data visualization on Coursera that has reached over 360,000 learners worldwide since 2016.

8. I serve as the Director of Online Programs for the Department of Computer Science at the University of Illinois, and oversee its Master of Com-

puter Science ("MCS") degree program. In 2016, I redesigned the online offering of the MCS degree program to make it more flexible and affordable for students that could not afford to leave their job to pursue a degree fulltime. Under my leadership, this degree program quickly grew to the second largest graduate program offered by the University of Illinois at Urbana-Champaign, and contributed significantly to the campus-wide proportion of underrepresented minorities enrolled in the institution. The tech company C3.ai found this online degree so desirable, it pays its employee's tuition and upon completion, gives them a bonus, a raise and stock options.

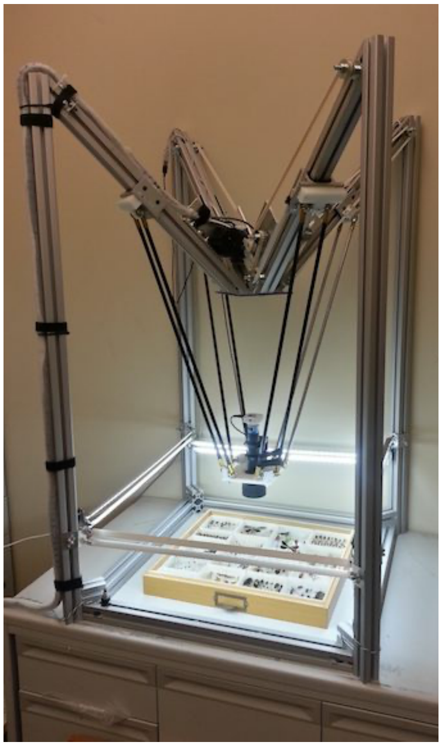
9. I am also the Executive Associate Dean of the Graduate College of the University of Illinois at Urbana-Champaign, where I oversee the education of over 17,800 graduate students in hundreds of graduate degree programs across the entire university. I recently developed a new post-baccalaureate certificate credential at Illinois to provide the recently unemployed with a rapid educational opportunity to transition their skills to areas of greater prosperity.

10. I have been researching computer graphics since 1987, with over a hundred papers, videos, patents and other contributions to computer graphics including photographic imaging systems. My work in computer

graphics has been funded by Adobe, Intel, Microsoft, Nokia and Nvidia as well as the National Science Foundation (NSF) and the Defense Advanced Research Projects Agency (DARPA). One of my most recent contribution is on the topic of displaying text on the video screen of a VR headset, in collaboration with Oculus. This paper, "Real-Time Analytic Antialiased Text for 3-D Environments," was selected as one of the best papers at the 2019 High-Performance Graphics Conference in Strasbourg France in July.

11. I am an internationally recognized leader in the field of computer graphics. From 2002-08 I was the Editor-in-Chief of the top journal in computer graphics, the Association for Computing Machinery (ACM) Transactions on Computer Graphics. From 1994-1999 I served on the executive committee of the main organization of computer graphics practitioners, the ACM Special Interest Group on Computer Graphics and Interactive Techniques (SIGGRAPH). I continue to oversee the peer review of major papers in the field through service as chair and member of various paper review committees. I am also a founding member of the editorial board of ACM Books, and the area editor for computer graphics.

12. This report is on the subject of photographic imaging systems. I have worked on a variety of methods and systems for the fusion of photographs. For example, in 2008 I was granted patent #7,365,744 "Method and Systems for Image Modification" on techniques for learning a surface appearance from one photograph and realistically applying it to a different surface in another photograph.



13. At the priority date of the '479 patent, I was funded by the National Science Foundation's Advanced Digitization of Biodiversity Collections to design and deliver an imaging infrastructure to scan the nation's entomological collections of insect drawers. This project, available at invertnet.org, required the fusion of 51,791 photographic images of small portions of insect drawers, vials and slides to make the collections available via the Internet as high-resolution zoomable composite images. This effort included the design and deployment of a custom robotic photographic imaging system, designed specifically to capture and fuse numerous photographs of each specimen drawer.

IV. LEVEL OF ORDINARY SKILL IN THE ART (POSITA)

14. I understand that in evaluating the validity of the '479 patent claims, the content of a patent or printed publication prior art should be interpreted the way a person of ordinary skill in the art would have interpreted the prior art as of the effective filing date of the challenged patent.

15. I understand that factors that may be considered in determining the level of ordinary skill in the art at the time of the effective filing date of the challenged patents include: (1) the educational level of the inventor; (2) type of problems encountered in the art; (3) prior art solutions to those problems; (4) rapidity with which innovations are made; (5) sophistication of the technology; and (6) educational level of active workers in the field.

16. Dr. Durand at ¶13 in each declaration believes "that a POSITA would include someone who had, as of the claimed priority date of the '479 Patent, a bachelor's or the equivalent degree in electrical and/or computer engineering or a related field and 2-3 years of experience in imaging systems including image processing and lens design." He further recognizes "that someone with less formal education but more experience, or more formal education but less experience could have also met the relevant standard for a

POSITA." My opinions in reply to Dr. Durand use this definition of a POSITA.

17. I understand that the '479 patent shares a specification with and claims priority to U.S. App. No. 14/365,711 filed June 16, 2014 and issued as U.S. Patent No. 9,185,291. (Ex. 1001, '479 patent at 1:7–29.) I understand that U.S. App. No. 14/365,711 was a § 371 application from international patent application PCT/IB2014/062180 filed June 12, 2014 and is related to and claims priority from U.S. Provision Patent Application No. 61/834,486 filed June 13, 2013. (Ex. 1001, '479 patent at 1:7–29.) I therefore understand that the effective filing date of the '479 patent is June 13, 2013.

18. I would have met the requirements of a POSITA on June 13, 2013. I have used the perspective of a POSITA at that time to form my opinions in reply to Dr. Durand's opinons.

V. RELEVANT LEGAL STANDARDS FOR OBVIOUSNESS

19. I have been informed of the legal standards for establishing patent invalidity in *inter partes* review proceedings before the Patent Trial and Appeal Board.

20. I understand that the petitioner must prove invalidity of a patent claim by a preponderance of the evidence, that is, the evidence must be sufficient to show that a fact or legal conclusion is more likely than not.

21. I understand that a claim may be anticipated if (1) the claimed invention was patented, described in a printed publication, or in public use, on sale, or otherwise available to the public before the effective filing date of the claimed invention; or (2) the claimed invention was described in a patent or published application, in which the patent or application names another inventor and was effectively filed before the effective filing date of the claimed invention.

22. I understand that, once the claims of a patent have been properly construed, the next step in determining anticipation of a patent claim requires a comparison of the properly construed claim language to the prior art on a limitation-by-limitation basis.

23. I understand that even if a patent claim is not anticipated, it may still be invalid if the differences between the claimed subject matter and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person of ordinary skill in the pertinent art.

24. I also understand that a patent may be rendered obvious based on an alleged prior art reference or a combination of such references plus what a person of ordinary skill in the art would understand based on his or her knowledge and the references. It is also my understanding that in assessing the obviousness of claimed subject matter one should evaluate obviousness over the prior art from the perspective of one of ordinary skill in the art at the time the invention was made (and not from the perspective of either a layman or a genius in that art).

25. I understand that a patent claim composed of several elements is not proved obvious merely by demonstrating that each of its elements was known in the prior art. There must be a reason for combining the elements in the manner claimed. That is, there must be a showing that a person of ordinary skill in the art at the time of the invention would have thought of either combining two or more references or modifying a reference to achieve the claimed invention.

26. I understand that an obviousness determination includes the consideration of the following factors: (1) the scope and content of the prior art, (2) the differences between the prior art and the claims at issue, (3) the level of ordinary skill in the art, and (4) objective evidence of nonobviousness.

27. I understand that, when available, so-called objective indicia of non-obviousness (also known as "secondary considerations" and or the real world factors) like the following are also to be considered when assessing obviousness: (1) widespread acclaim; (2) commercial success; (3) long-felt but unresolved needs; (4) copying of the invention by others in the field; (5) initial expressions of disbelief by experts in the field; (6) failure of others to solve the problem that the inventor solved; and (7) unexpected results, among others. I also understand that evidence of objective indicia of non-obviousness must be commensurate in scope with the claimed subject matter. I understand this is commonly referred to as a "nexus."

28. I understand that the burden is on the petitioner to explain how specific references could be combined, which combinations of elements in specific references would yield a predictable result, and how any specific combination would operate or read on the claims. I further understand that the petitioner cannot rely on conclusory statements but must instead provide a reasoned explanation supported by evidence. I also understand that obviousness does not exist where the prior art discourages or teaches away from the claimed invention. I also understand that even if a reference does not teach away, its statements regarding preferences are relevant to ta finding whether

a person skilled in the art would be motivated to combine that reference with another reference.

29. I understand that it is impermissible to use hindsight to arrive at the claimed invention. My understanding is that the inventor's own path never leads to a conclusion of obviousness. I also understand that, when assessing whether there was a motivation to combine references to teach a claim element, defining the problem in terms of its solution reveals improper hindsight.

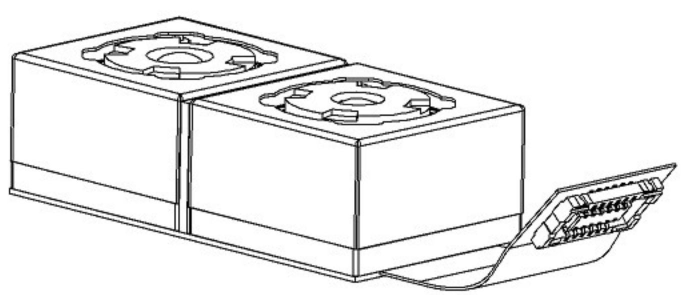
30. I understand that, in this proceeding, prior art to the '479 patent includes patents and printed publications in the relevant art that predate the effective filing date of the '479 patent's challenged claims, which I understand to be June 13, 2013. (Ex. 1001, '479 patent at 1:7–20.)

VI. OVERVIEW OF THE '479 PATENT

31. The '479 patent describes and claims techniques for making "thin digital cameras with optical zoom operating in both video and still mode." (Ex. 1001, '479 patent at 3:27–28.) As the patent explains, zoom in "commonly understood as a capability to provide different magnifications of the same scene and/or object by changing the focal length of an optical system." (Ex. 1001, '479 patent at 1:44–49.) Traditionally, this was accomplished by mechanically moving lens elements relative to one another. (Ex.

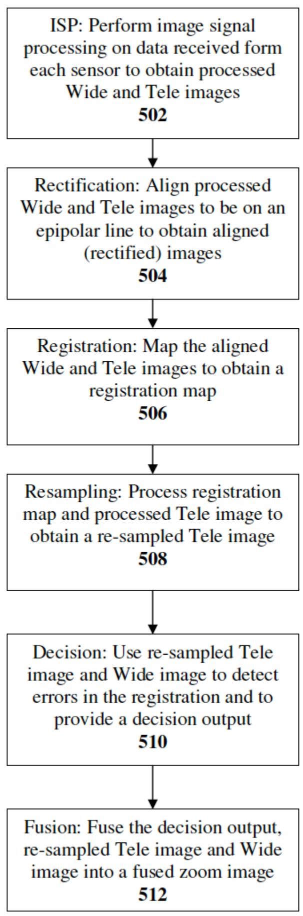
1001, ’479 patent at 1:49–51.) Another approach is “digital zooming,” where the focal length of the lens is kept unchanged, but the image is cropped and digitally manipulated to produce an image that is magnified but has a lower resolution. (Ex. 1001, ’479 patent at 1:55–38.)

32. The ’479 patent describes an approach to approximating the effect of a zoom lens (which varies its focal length) by using two lens systems (a “wide” and a “tele” lens system) with different fixed focal lengths. (Ex. 1001, ’479 patent at 3:34–54.) Various computational means are used to take the images from these two lenses to produce an output that approximate a system with mechanical zoom. This approach can produce a device that is smaller, lower cost, and more reliable than devices that use mechanical zoom. (Ex. 1001, ’479 patent at 1:51–53.)



(Ex. 1001, ’479 patent, Fig. 1B)

33. Relevant to the claims of the '479 patent, the specification describes combining still images using the technique of "fusion." (Ex. 1001, '479 patent at 3:48–54.) A "fused" image includes information from both the wide and tele images. (Id.) One approach to performing fusion is shown in Figure 5:



(Ex. 1001, '479 patent, Fig. 5.)

34. Making a compact, high-quality dual-aperture zoom system requires lenses with particular characteristics. The '479 patent teaches lens designs for the tele lens which provide a small "total track length" relative to their focal length, which means that they have a compact size in light of the degree of magnification that they provide. (Ex. 1001, '479 patent at 12:38–53.) One of the lens designs taught by the '479 patent and covered by several of the challenged claims is shown in Figure 9:

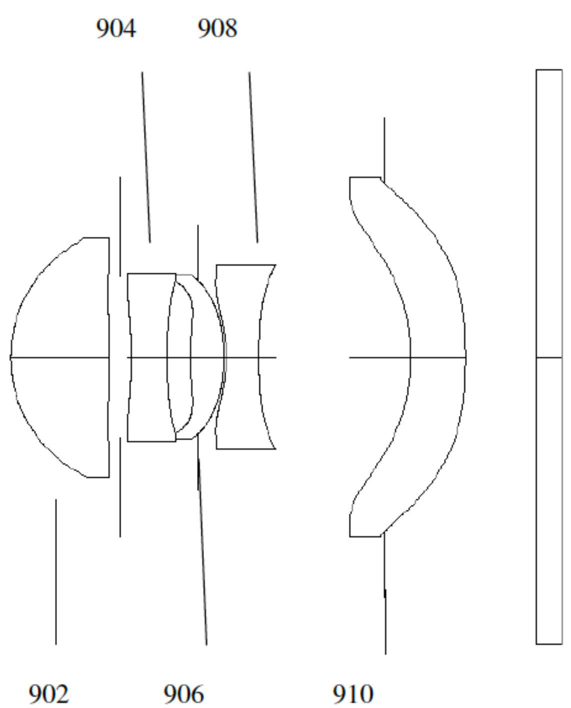


FIG. 9

(Ex. 1001, '479 patent, Fig. 9.)

35. The lens aspects of the '479 patent are described further in Dr. Moore's declaration. (E.g., Ex. 2015, Moore Decl., ¶¶ 31–34.)

VII. CLAIM CONSTRUCTION

A. "fused image with a point of view (POV) of the Wide camera" (claims 1 and 23)

36. Dr. Durand's opinion is that this term should be construed as "a fused image that maintains the Wide camera's field of view or both the Wide camera's field of view and position." (Ex. 1003 from -00905 IPR, ¶¶ 29–33.) I do not agree that is the understanding of this term to a POSITA, in view of the '479 patent.

37. Under this construction there are two ways to meet the "point of view" requirement. Either, the fused image can maintain the Wide camera's (a) field of view or (b) field of view and position. However, the second of these two options is superfluous, as if the image has both the field of view and position of the Wide camera, then it also necessarily has the field of view of the Wide camera. So, Dr. Durand's construction is logically equivalent to the construction "a fused image that maintains the Wide camera's field of view."

38. Even the superfluous "Wide camera's . . . position" portion of the construction does not line up with the term "position" as it is used in the '479 patent's discussion of "POV." During his deposition, Dr. Durand confirmed that he understood the "Wide camera's . . . position" to refer to the "3D XYZ location of the camera." (Ex. 2036, Durand Depo. at 21:3–7.) But

when the specification refers to "position POV" in its discussion of "combination" POVs, it is referring to the "position of either sub-camera *image*." (Ex. 1001, '479 patent at 5:14–16.) That is, "position POV" is based on the positions of images, not the positions of cameras. An image position may differ because the camera is located in a different position, but it also may differ because camera, located in the same position, has been pointed in a different direction. For this reason as well, Dr. Durand's proposed construction is inconsistent with how the patent specification uses the relevant terms.

39. The effect of Dr. Durand's construction is to replace the term "point of view" in the claims with the term "field of view" in his construction. This is not consistent with how a POSITA would understand these phrases or with how they are used in the '479 patent. For example, claim 1 refers to both "a field of view FOV_W" of the wide camera and "a point of view (POV)" of the wide camera, with no suggestion they are the same thing or that one term is the antecedent basis for the other. (Ex. 1001, '479 patent at 13:25–26, 13:48.)

40. In the specification, the '479 patent clearly defines "FOV" as a planar angle, representable in degrees: "As used herein, the FOV is measured from the center axis to the corner of the sensor (i.e. half the angle of the normal

definition).” (Ex. 1001 at 7:11–13.) Examples of FOV values are given in degrees (id. at 7:20–22), and FOV is used as a parameter to the tangent function, further confirming that it is a simple angle (id. at 7:7–8).

41. Dr. Durand agreed during his deposition that his construction of “POV” matches what the patent calls field of view:

> Q. So when you’re using the term “field of view” in this construction, you’re reviewing -- you're referring to how much of the scene is captured by the camera; is that right?
>
> A. This is a vague version of the definition, I would say one definition of the field of view. For example, the horizontal field of view is to look at the angle between the two edges of the -- of the image.

(Ex. 2036 at 22:4–12.)

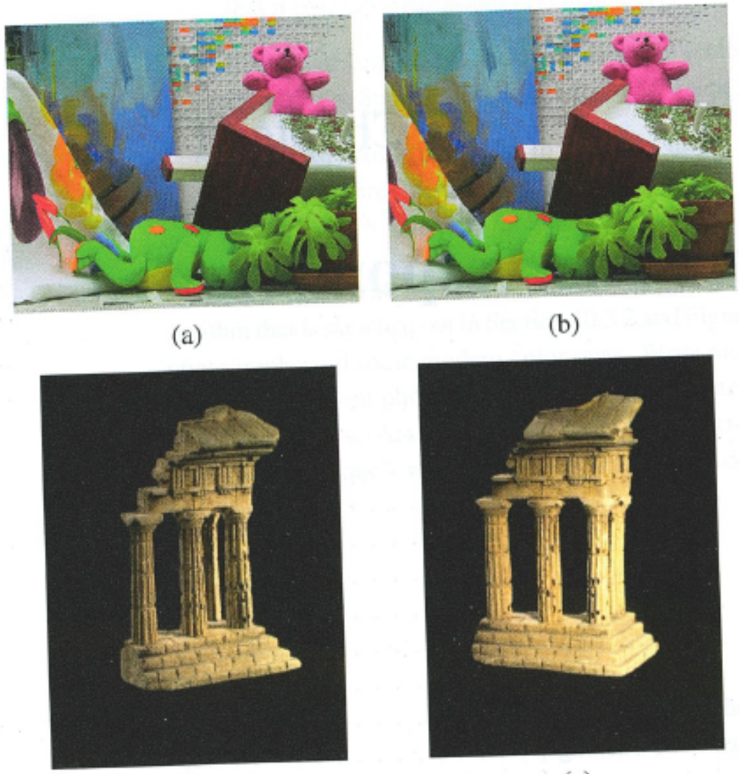
42. This is definition matches what the ’479 patent specification calls the “normal definition” of FOV (the ’479 patent uses half that “normal” value in its formulas). (Ex. 1001, ’479 patent at 7:11–13.) As Dr. Durand testified, this FOV is an inherent property of the camera and lens, and independent of where they are pointed or what they see:

> Q. Would you agree that a camera’s field of view is a property of the camera that’s independent of what direction the camera is pointing?
>
> A. So one definition or understanding of field of view would be -- would indeed be just an angle that’s a property of the combination of a camera and the lens.

(Ex. 2036 at 22:25–23:6.)

43. POV is defined in the specification quite differently. It refers to how objects are "seen by each sub-camera," i.e., how objects "with be shifted and have different perspective (shape)" for the two cameras. (Ex. 1001 at 5:10–14.) This POV depends on the position and orientation of the camera and cannot be expressed fully by a single numerical angle. Rather, as the '479 patent explains, using a camera with a different POV can both shift an object (change its position in the image) and change the perspective of an object (changes its apparent shape in the image). (Ex. 1001 at 5:10–16.)

44. Examples of changing POV can be seen in image pairs (a)-(b) and (d)-(e) from Szeliski Figure 1.1:



(a) (b) (d) (e)

(Ex. 1013, Szeliski at 468.)

45. The ’479 patent refers to “combination” possibilities where an output image reflects only some aspects of a given POV, such as “Wide perspective POV” or “Wide position POV.” (Ex. 1001, ’479 patent at 5:15–19.) But, when it refers to “Wide POV,” without qualification, it is referring to the complete Wide POV, both perspective and position. (Ex. 1001, ’479 patent at 5:10–14; 5:23–26.)

46. In summary, a POSITA would not agree that the term POV in the phrase “fused image with a point of view (POV) of the Wide camera” can

be replaced with the distinct term FOV. Further, a POSITA would understand that POV of the Wide camera in this phrase refers to the full Wide camera POV and not to "combination" outputs that have a Wide "perspective POV" and Tele "position POV" or vice versa. (Ex. 1001, '479 patent at 5:13–23.) In my opinion a POSITA would understand this term to mean "fused image in which the positions and shapes of objects reflect the POV of the Wide camera."

B. "to find translations between matching points in the images to calculate depth information and to create a fused image suited for portrait photos" (claim 19)

47. Dr. Durand's opinion is that this term appearing in claim 19 should be construed "as requiring the claimed camera controller to (1) 'find translations between matching points in the images to calculate depth information' and (2) 'creating a fused image suited for portrait photos.'" (Ex. 1003 from -00906 IPR, ¶¶ 31–35.) This construction repeats the words from the claim term verbatim, so it is not seeking to construe particular words with technical meaning to a POSITA. Rather, the construction offers a particular way of parsing the grammar, arguing that the two parts of the term on either side of the word "and" are independent steps, and that nothing prior to the word "and" modifies anything after the word "and." In particular, Apple and

Dr. Durand appear in this construction to be avoiding having to demonstrate that the "translations between matching points in the images" are used as part of the "create a fused image" process.

48. This construction fails to capture the plain meaning of the phrase, in view of the '479 patent specification. First, focusing just on the phrase Dr. Durand construes, the phrase has three verbs in the infinitive "to" form: "to find . . . to calculate . . . and to create . . . ." It appears in a larger phrase (surrounded by commas) with four infinitive verbs: "to process . . . to find . . . to calculate . . . and to create . . . ." (Ex. 1001, '479 patent at 15:28–32.) The "and" joins "to create" with one of the other "to" verbs. The most natural "to" verb to connect it with is the closest one, "to calculate," not one of the earlier ones as suggested by Dr. Durand.

49. Looking at the broader phrase, a POSITA would recognize that the "creat[ing] a fused image" is part of the broader "to process the Wide Tele images" step. Each of the other independent claims (1 and 23) contain the phrase "[to process/processing] the Wide and Tele images to create a fused image." (Ex. 1001, '479 patent at 13:43–44, 15:61–62.) Likewise, in the specification, the output of the fused image is described part of "processing" the images. (Ex. 1001, '479 patent at 3:64–65 ("Processing is applied on the two

images to fuse and output one fused image in still mode."), 7:57–58 ("image processing that fuses the Wide and the Tele images to achieve optical zoom")). In the context of the '479 patent, "creat[ing] a fused image" is understood as part of "process[ing] the Wide and Tele images," meaning that the whole larger phrase "to process the Wide and Tele images to find translations between matching points in the images to calculate depth information and to create a fused image suited for portrait photos" combines a single process, not distinct and unrelated processes as suggested by Dr. Durand's construction.

VIII. PRIOR ART REFERENCES

50. In this section, I discuss the Parulski reference, which is used in each of Apple's obviousness combinations for the '479 patent, in detail. Dr. Moore has provided a detailed discussion of the Kawamura and Ogata references in his declaration, which I refer to where appropriate. I discuss the other prior art references in the contexts of specific claim limitations where relevant.

A. Parulski

51. The Parulski patent was published as U.S. Patent No. 7,859,588 and issued on December 28, 2010. (Ex. 1005.) It was filed on March 9, 2007. (Ex. 1005, Parulski, at 1.)

52. Parulski at the Summary of the Invention includes an overview of the preferred embodiments and their motivations at 7:54 – 8:19. These embodiments include the use of the secondary image from the additional lens "to sharpen portions of the primary image … where the secondary output image is captured … at a different focus position … ; to modify the dynamic range of the primary image … ; to provide scene analysis data for setting the capture parameters for the primary image; or to replace portions of the primary image … with corresponding portions of [a longer exposure] secondary image." Id. at 7:56-8:5. As this list suggests, these various preferred embodiments are designed to achieve different results, and they take different approaches to doing so. A POSITA would not understand all of Parulski's specification (or all of the portions cited by Apple and Dr. Durand) to be part of the same embodiment or even to be compatible with one another.

53. Parulski discloses a camera system comprising "the use of two (or more) image capture stages, wherein an image capture stage is composed of a sensor, a lens and a lens focus adjuster, in a multi-lens digital camera in which the two (or more) image capture stages can be used to separately capture images of the same scene so that one image capture stage can be used for

autofocus and other purposes while the other(s) is used for capturing an image." Id. at 8:6-13. "More specifically, the non-capturing image stage may advantageously be used to provide a secondary image that can be used to modify or otherwise augment, e.g., the focus or dynamic range of the primary image." Id. at 8:16-19.

54. Parulski uses Figure 1 reproduced below to illustrate an "image capture assembly" including "two imaging stages 1 and 2." Id. at 12:42-43. The image capture stages 1 and 2 comprise the zoom lenses 3 and 4 and the image sensors 12 and 14… ." Id. at 12:66-67. Lenses 3 and 4 "have different focal lengths to provide and extended optical zoom range for the image capture assembly." Id. at 10:15-17.

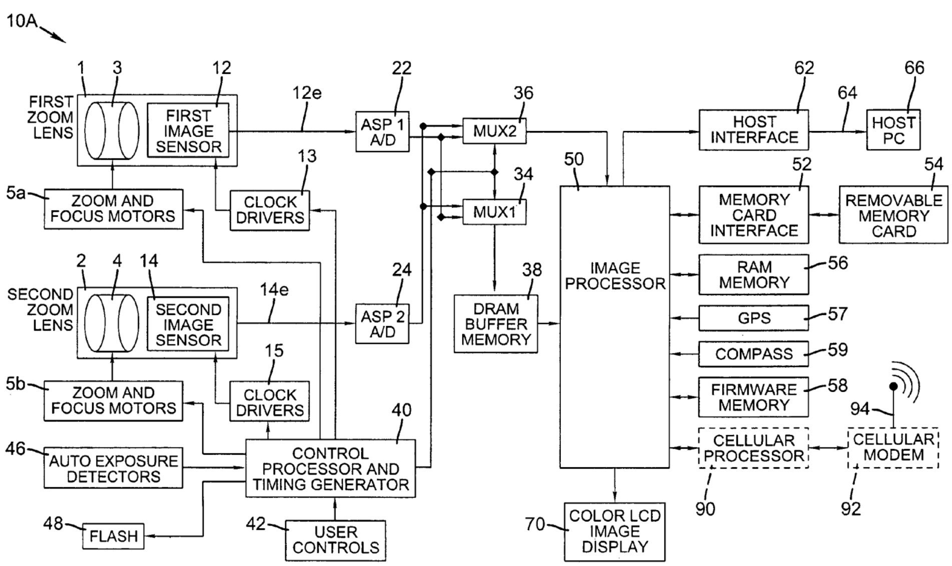


FIG. 1

55. Parulski discloses that this design can facilitate autofocusing. "The control processor and timing generator 40 controls the digital multiplexers 34 and 36 in order to select one of the sensor outputs (12e or 14e) as the captured image signal, and to select the other sensor output (14e or 12e) as the autofocus image signal." Id. at 14:1-5. "Briefly summarized, the image processor 50 produces the focus detection signals that drive the first and second focus adjusters, that is, the zoom and focus motors 5a and 5b."

56. Parulski uses Figure 3, reproduced below, to show how the image capture assembly in Figure 1 is used to capture images.

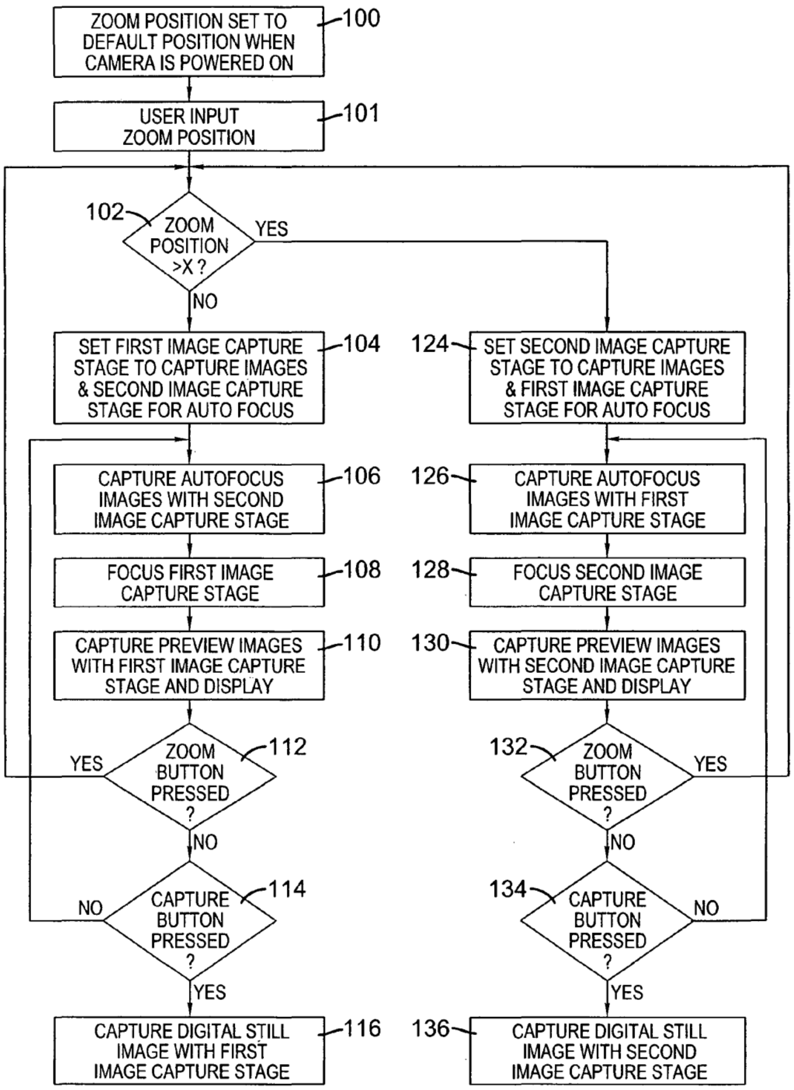


FIG. 3

57. The decision at block 102 uses the zoom position to determine whether the first stage (image capture stage 1 in Fig. 1) or the second stage (image capture stage 2 in Fig. 1) has the more appropriate focal length for that zoom setting. As an example, we can assume that the zoom position is not

greater than X and the steps on the left hand side of Fig. 3 starting with 104 are selected, previewing images from the first stage and using the second stage to assist the autofocus of the first stage.[2]

58. Block 108 represents the step in Fig. 3 that represents the action of the image processor (block 50 in Fig. 1) that accesses the images captured by both stage 1 and stage 2. "In block 104 … the first image capture stage 1 is used to capture images in the preview mode, while the second image capture stage 2 is used to capture autofocus images. The first image capture stage 1 continues to capture images for preview on the display 70 (block 110) while, in block 106, the second image capture stage 2 is used to capture autofocus images for autofocus of the first image capture stage 1, which are processed by the image processor 50 and used in block 108 to focus the first image capture stage 1." Id. at 15:57-67.

59. Parulski discloses three options for block 108: "rangefinder," "hill climbing" and "rangemap."

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[2] During his deposition, Dr. Durand testified that the only situation where he had offered an opinion that Parulski satisfied the necessary claim elements was when the zoom position equals 1 (no zoom) and the output field of view equals the wide image view of view. (Ex. 2036, Durand Depo. at 64:20–65:3, 65:18–67:5.) Given that this is Dr. Durand's position, the case where the zoom position is greater than X is not relevant to Dr. Durand's opinions.

60. The "rangefinder" option is shown in Fig. 4, reproduced below Step 258 indicates that the shutter button is pressed halfway down (S0 → S1), initiating autofocus. "The cropped and upsampled autofocus image is then correlated with the other autofocus image to identify the pixel shift[3] between the two autofocus images (block 264) and thereby produce the focus detection signal." Id. at 16:54-58. Step 266 indicates a "rangefinder calibration curve" is used to convert the "focus detection signal" into the single value sent by step 268 to focus the "first image" in block 108 of Fig. 3.

[3] The phrase "the pixel shift" combined with the "rangefinder" designation would be understood by a POSITA at the time that a single value indicating the distance from the camera to a desired focal point in the scene is desired. A POSITA would thus understand "the pixel shift" to be either the disparity of one pixel location correlated between the two images, or an average disparity of a region of pixels correlated between the two images. A POSITA would understand from Parulski's disclosure of the computation of the "rangefinder calibration curve" at 17:60-18:11, Figures 6 and the demonstrations of pixel regions shown in Figures 17A and 17B, that a single pixel disparity or an average disparity in a small region of pixels is used as the input to the "rangefinder calibration curve." A POSITA would understand a "calibration curve" to be a function accepting a single value and returning a single value, whereas a POSITA would understand a function accepting more than a single value to be referred to as a "calibration surface" or a "calibration manifold." A POSITA would not understand "the pixel shift" to require the computation of a rangemap. Furthermore, the computation of a rangemap is not inherent in Parulski's disclosure of "the pixel shift" used for the "rangefinder" autofocusing method.

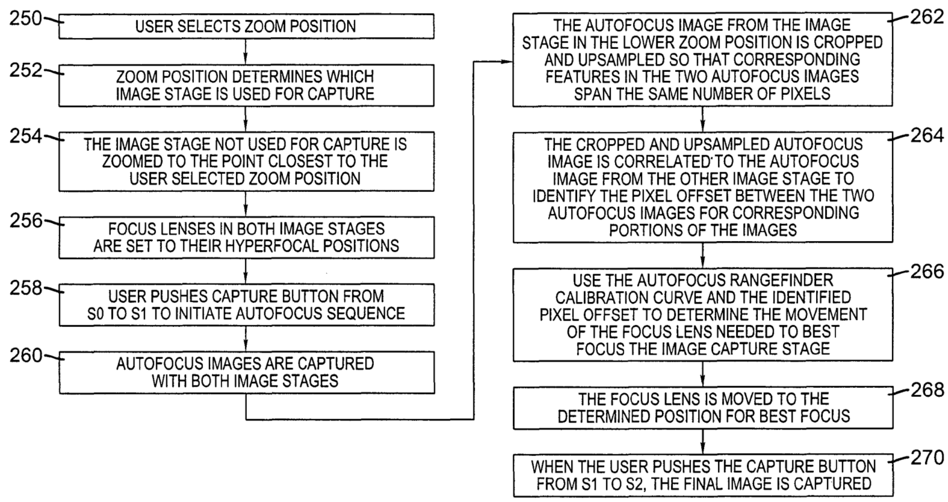


FIG. 4

61. The "hill climbing" option is illustrated in Fig. 5 and disclosed by Id. at 17:7-56. It uses the second capture stage to experimentally adjust its focus to maximize contrast to find the optimal focus setting for the first capture stage. The advantage of this approach is that the iterated adjustments in the second capture stage can remain hidden while the user observes the preview image updated in the first capture stage, even while adjusting zoom settings or reorienting the camera to different focal points in the scene.

62. The "rangemap" option is illustrated in Fig. 11, reproduced below, and disclosed by Id. at 21:49-22:49[4]. The "rangemap" option uses the

[4] This rangemap is an option for Fig. 3 (Id. at 21:49-51) and specifically block 108, since "[c]ertain parts of the diagram bear the same functions and reference characters as used in Fig. 9" (Id. at 21:51-53) and "… a

rangefinder calibration curve in block 482. Whereas a single pixel offset is used to produce a single range value in the “rangefinder” option, block 482 shows that the “rangemap” option determines “the distances to different portions of the images.” Id. at 20:15.

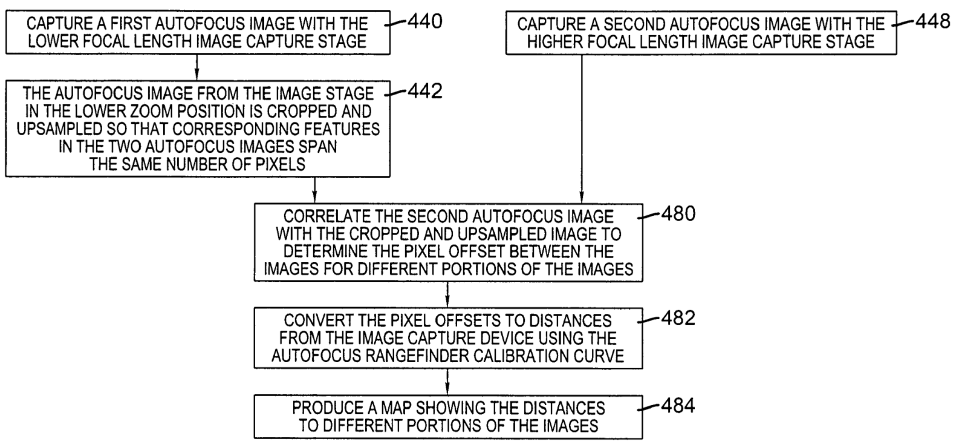


FIG. 11

63. This range map is described as being usable “for a variety of purposes” (id. at 20:51–21:6), but it is noteworthy that none of the example uses listed in the specification involves “fusing” or otherwise combining image data from the two images. The first three example all involve identifying object boundaries or motion tracking of objects, which does not have anything

rangefinder configuration is shown in Fig. 9, where the rangefinder method is used in blocks 108 and 128…” (Id. at 19:61-63). (Fig. 9 refers to blocks 108 and 128 in Fig. 8, which targets video whereas Fig. 3 targets still images.)

to do with fusion, per se. (Id. at 20:54–62.) The fourth example describes blurring portions of the output image. (Id. at 20:63–65.) The last three examples describe increasing or decreasing the brightness of portions of the image. (Id. at 20:66–21:6.)

64. A POSITA would not understand the discussion of "blurring" in connection with Fig. 11 (id. at 20:63, 21:36–44) to be referring to fusing two images. Rather a single image (or portions of the image) can be digitally blurred using a variety of techniques. Generally speaking, blurring an image involves reducing the magnitude of the high-frequency components of a image, while leaving the low-frequency components alone. This has a similar effect to that of averaging the brightness values of the pixels in each local portion of the image. One approach to blurring is to calculate the Fourier transform of an image to compute its frequency components, reduce the high frequency components using a filter, and then perform an inverse Fourier transform on the result. This general approach is described, for example, in the Morgan-Mar reference that Apple relies on in the -00906 IPR. (Ex. 2037, Morgan-Mar at 3:36–54.)

65. Likewise, the discussion of the dog being "sharpened" would not be understood by a POSITA to refer to fusing two images. (Ex. 1005 at 21:30–

31.) The same Fourier transform techniques used to blur can be used instead to sharpen—e.g., making edges in the image more prominent—by increasing the high-frequency components rather than decreasing them. This is also explained in Morgan-Mar: "In the Fourier domain, N is not constrained to being an integer. As long as N>1, the blurring of the background is increased. If N<1, the blurring of the background is reduced; in other words the background is sharpened, mimicking the effect of a greater depth of field than the original images." (Ex. 2037, Morgan-Mar at 11:33–38.)

66. Whereas "Fig. 3 depicts a flow diagram showing a method for performing autofocus and for capturing digital still images according to a first embodiment of the digital camera shown in Fig. 1" and "Fig. 8 depicts a flow diagram showing a method for performing autofocus and for capturing digital video images according to a first embodiment of the digital camera shown in Fig. 1[,]" "Fig. 14 depicts a flow diagram showing a method for enhancing the depth of field of an image by using images from both image capture stages according to an embodiment of the invention." Id. at 8:34-37, 48-51 and 9:1-4. Parulski identifies a special, different method for "enhancing the depth of field of an image" than was disclosed for "performing autofocus and for capturing digital still images."

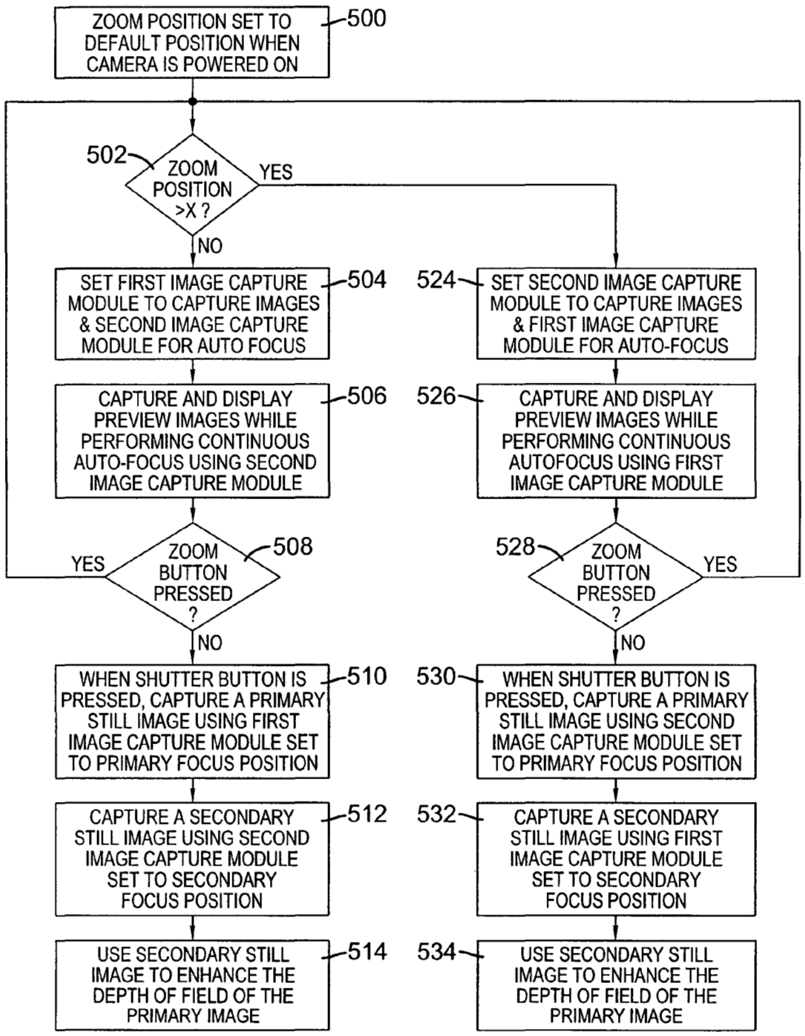


FIG. 14

67. As before, we can assume without loss of generality that the zoom position is not greater than X and focus the discussion on the left side of the flow diagram starting with block 504. In blocks 504 and 506, the first image capture stage is used to capture and preview images while the second image capture stage is used to "capture autofocus images for autofocus of the

first image capture stage." Id. at 22:28-29. When the shutter button is pressed, then block 510 indicates a primary still image is captured from the first image capture module and block 512 indicates a secondary still image is captured from the second image capture module.

68. Block 514 indicates that the secondary image is used to enhance the depth of field of the primary image. "Then, in block 514, the secondary still image is used to enhance the depth of field of the primary image, for instance, where the secondary still image is used to provide an enhancement signal that can be used to sharpen portions of the primary still image that are positioned near the secondary focus distance." Id. at 22:35-42.

69. This description of the "enhancement signal" is unclear. The term "enhancement signal" appears at 12:17-18, 22:40,63 and 23:1, where it is used to "e.g., sharpen portions of the primary still image that are positioned near the secondary focus distance" (Id. at 12:18-20), or "to sharpen portions of the primary still image that are positioned near the secondary focus distance" (Id. at 22:40-42, 64-65 and 23:2-3). The enhancement signal is "generated by the camera" or is "generated by the eternal processor" (Id. at 22:63-23:3) but without any disclosure of what is generated or how it is generated.

70. The term “range map” never appears in Parulski’s disclosure of enhancing the depth of field at 22:14-23:3. Furthermore, this disclosure of enhancing the depth of field describes a different flow diagram (Fig. 14) than the ones capable of producing a range map (Figs. 3 and 8). It would not be obvious to a POSITA how to modify the method shown in Fig. 14 to generate both a range map and to autofocus the images captured by both stages.

71. Assuming the “enhancement signal” were a range map (which is never suggested by Parulski), however, the discussion of Figure 14 in column 22 of Parulski does not describe a “fused image,” because sharpening using a range map would involve sharpening the edges present in specific portions of the primary still image, rather than transferring image data from the secondary still image into the output image. (Id. at 22:37–42.)

IX. OBVIOUSNESS—CLAIMS 1 AND 23 (AND DEPENDENTS)

A. A POSITA Would Not Have Found Obvious the Combination of Parulski and Konno (Ground 1, -00905 IPR)

72. Dr. Durand uses hindsight and to combine cherry-picked portions of embodiments of Parulski to create a Frankenstein embodiment that Parulski neither disclosed nor preferred. In his analysis for limitations [1.5.1] and [1.5.2] (Ex. 1003 in -00905 IPR, Durand Decl. at 47–53), and thus in his

analysis for limitations [23.3] and [23.4], which simply refers back to these limitations (id. at 63), he relies on three portions of Parulski: (1) 20:1–15, 20:50–59, and 21:34–44 discussing Figure 11; (2) 22:14–42 discussing Figure 14; and (3) 28:45–57 discussing Figure 26.

73. Figure 11 describes a method "wherein a range map is produced." (Ex. 1005, Parulski at 19:49–51.) The Figure 11 discussion is the only portion of Parulski that Dr. Durand cites as satisfying the "by mapping Tele image pixels to matching pixels within the Wide image" portion of limitation [1.5.2]. (Ex. 1003, Durand Decl. at 52–53.) However, as explained above, nothing in the discussion of Figure 11 describes using the range map as part of a system that outputs a "fused image." Identifying objects within an image, tracking motion, blurring portions of an image, or adjusting gain would all be understood as operations that could utilize a range map, but would not need to fuse image data from two different images. Likewise, the image capture assemblies of Figures 3 and 8, which Parulski says Figure 11's method uses, do not fuse data from two different images. (Ex. 1005, Parulski at 19:49–51.)

74. Nowhere else does Parulski describe using the Figure 11 method together with image fusion. Indeed, the only reference to using the Figure 11 method (or any "range map") at all in the rest of Parulski describes using the

range map, together with GPS location and direction information to determine the geographic locations of portions of the scene. (Id. at 24:52–25:15.)

75. Dr. Durand cites the motivation of focusing on both a foreground dog and a background mountain of Parulski at 21:7-44. However, nothing in the passage describes combining portions of the wide and tele images. The paragraph describes a series of modifications to a wide image that can be made without directly incorporating image data from the tele image, or using the tele image for any reason other than generating range data. It describes "applying gain adjustments to . . . portions ***of the image***" (id. at 21:17–24), which can readily be done directly to the wide image data. Likewise, "blurring" and "sharpening" can be done directly on the wide image data (using for example the Fourier transform techniques discussed above), without importing image data from elsewhere. Indeed, the blurring and sharpening described would, in general, need to work without importing tele image data. This is because background objects in the wide image, such as the mountains in Parulski's example will generally extend beyond the area visible in the tele image, and limiting the blurring or sharpening to the regions visible in the tele image would not achieve the results described in Parulski.

76. The description of an image that has both the dog and the mountains in focus, with the intermediate parts of the scene blurred, (id. at 21:40–44) would be achieved using image data from the wide image, without any need for importing image data from the tele image. The dog is described as being "5 feet away" (id. at 21:12–13), and Parulski teaches that a single wide angle lens, set to its hyperfocal distance, will have objects from 4 feet to infinity in focus (id. at 21:59–61).

77. As for the discussion of Figure 14 and Figure 26, neither mentions using a range map, and neither provide any detail on how the two images are fused, if at all. The Figure 14 discussion refers to use of an "enhancement signal that can be used to sharpen portions of the primary still image." (Id. at 22:39–42.) Parulski does not specify that the enhancement signal actually contains image data from the secondary image, and it does not specify how the enhancement signal is used. As explained above, sharpening can be performed to enhance edges based solely on the data from a single image. Thus, the enhancement signal could be something as basic as a signal telling the system to sharpen a particular portion of the primary image, without containing any information about depth or any image data from the secondary image.

78. The Figure 26 discussion states that "the two images are combined into a modified image with a broadened depth of field." (Id. at 28:52–53.) However, it says nothing at all about how the images are "combined" or what the characteristics of that image are beyond the "broadened" depth of field.

79. Even assuming that a POSITA would cobble the cherry-picked quotes from Dr. Durand's analysis into a new system, as Dr. Durand suggests, Dr. Durand has not shown that this new system would satisfy the "fused image with a point of view (POV) of the Wide camera" limitation, under its proper construction. Dr. Durand's sole argument that Parulski meets this limitation is based on the output image having the "wide image's field of view." (Ex. 1003, Durand Decl. at 51.) He does not even address the optional portion of his proposed claim construction, "the Wide camera's . . . position." Dr. Durand confirmed that his sole theory for satisfying the POV limitation was based on the output FOV during his deposition, when he testified that his only theory for infringement was when the zoom position equals 1 (no zoom) and

the output field of view equals the wide image view of view. (Ex. 2036, Durand Depo. at 64:20–65:3, 65:18–67:5.)[5]

80. As I explained above, the '479 patent's discussion of POV defines it with respect to shapes (perspectives) and positions of the objects within images. (Ex. 1001, '479 patent at 5:11–33.) Nothing in this discussion even suggests that FOV is relevant to the question of POV, let alone that it is the same thing. Nothing in Parulski suggests that whatever image data from the tele image that might be "fused" into the output would be modified to have the shapes and positions from the wide image POV. And nothing in Dr. Durand's declaration even attempts to establish this would be true. As a result, Dr. Durand has failed to show that any combination of Parulski with the other references satisfies the limitations of the independent claims. Since Dr. Durand has not offered any other theory for how Parulski or any other prior art reference satisfies the "fused image with a point of view (POV) of the Wide camera" limitation in any of the claims challenged in the -00905 IPR, he has

[5] The questions asked of Dr. Durand here appear to conflate "X" with the zoom position, rather than being a threshold value of the "X" position where the primary and secondary image capture modules switch roles. Presumably, this reflects a misreading of Parulski's figures by the questioning attorney. However, Dr. Durand's answers are clear that he believes Parulski only meets this limitation when no zoom is applied to the wide image and the output image has the same field of view as the wide image.

also failed to demonstrate that any obvious combination of references satisfies any of these challenged claims under any ground.

B. A POSITA Would Not Have Found Obvious the Combination of Parulski, Konno and Szeliski (Ground 2, -00905 IPR)

81. Dr. Durand opines regarding Claim 2 at pp. 71-71 that "[a] POSITA would have recognized that applying Szeliski's rectification process to Parulski's cell phone camera would yield rectified Wide and Tele images" and that "[a] POSITA also would have understood that these rectified images would then be used in Parulski's method for performing more efficient pixel matching in deriving the range map." However, Parulski was filed Mar. 9, 2007, and image rectification was already well known to a POSITA at that time. For example, image rectification was covered in the popular textbook "Computer Vision: A Modern Approach" by Forsyth and Ponce (First Edition), published by Pearson in 2003, pp. 325–26. If rectification was an obvious improvement to Puralski to a POSITA on June 13, 2013, then it would have been an obvious improvement to Puralski to a POSITA (including Puralski) on Mar. 9, 2007.

82. Dr. Durand cherry-picked rectification from Szeliski in a hindsight attempt to modify Parulski toward the '479, and provides no reason why a POSITA would use rectification over other alternatives. Szeliski §11.1.1

"Rectification" is immediately followed by §11.1.2 "Plane sweep" which is "[a]n alternative to pre-rectifying the images before matching… ." (Ex. 1013, Szeliski at p. 474.) "The choice of virtual camera and parameterization is application dependent and is what gives this framework a lot of its flexibility. In many applications, one of the input cameras (the reference camera) is used, thus computing a depth map that is registered with one of the input images." Szeliski at p. 475. Hence the plane sweep would be useful for constructing a range map, especially for the '479, because its depths would be registered specifically with respect to the Wide image point of view.

C. A POSITA Would Not Have Found Obvious the Combination of Parulski, Konno, Szeliski and Segall (Ground 3, -00905 IPR)

83. Parulski is directed at a camera consisting of multiple image capture stages, whereas Segall, in particular the portions cited by Dr. Durand, is directed at devices consisting of a single image capture stage. Parulski's registration relies on "Stereo-Based Image Processing" (Parulski at 19:53-20:49) whereas Segall's registration relies on "motion estimation" (Segall at 4:33-5:23). A POSITA would have understood that the registration produced by the simple global "epipolar" disparity of stereo images from multiple simultaneous photographs would have fewer errors than would the registration obtained through motion estimation of a sequence of frames with a single

moving camera as well as an articulated scene with multiple surfaces moving in different directions.

84. Furthermore. Segall's "Mis-Registration Detection" cited by Dr. Durand's four line excerpt of Segall was actually the introduction of an entire section of Segall 6:43-9:61 including portions on temporal consistency and other issues of motion compensation registration that a POSITA would have realized would have added significant wasted effort when applied to a simpler and less error-prone stereo registration.

D. A POSITA Would Not Have Found Obvious the Combination of Parulski, Konno and Stein (Ground 4, -00905 IPR)

85. The '479 includes a clever scheme for synchronizing the rolling shutter signals of its Wide and Tele CMOS sensors. One of the objectives of this design was to "minimize the required bandwidth from both sensors for the ISPs" ('479 at 7:56-57). Another objective is that "matching FOV's in both images (Tele and Wide) are scanned at the same time" but this would have little impact in anything other than trick photography that reveals the limits of a CMOS sensor by setting the exposure time too fast.

86. Dr. Durand opines that it would have been obvious for a POSITA to combine Parulski and Konno with Stein to incorporate the latter's synchronization of a CMOS shutter to produce a similar result to '479. I disagree for several reasons.

87. First, the POSITA would have needed to be motivated to seek this synchronization. Parulski's examples, including landscapes with mountains, flowers and a sitting dog, provide little high-speed motion to motivate the need for careful synchronization of the image signals. Parulski's design also provides little motivation for the need of increased bandwidth between sensors and processors, as Parulski design includes an interface to an external PC that can be used in the computation of a range map.

88. Second, even if a POSITA was motivated to reduce the bandwidth needed between the sensors and the processor, the POSITA would not have looked to the automotive industry for a solution. The synchronization of CMOS sensors is important to Stein not because of any reduction in bandwidth, but because multiple vehicle cameras have to register fast moving scenes, so it is important that the rolling shutters are synchronized. Cameras used for driver assistance systems do not provide images intended for human viewing, and are less concerned with rolling shutter image artifacts than the

images produced by the cameras of the ‘479. The fact that two very different problems (fast scene registration for Stein v. bandwidth reduction for ’479) were solved by a similar synchronization approach is coincidental. The combination of Stein with Parulski is due not to obviousness, but to hindsight.

X. OBVIOUSNESS—CLAIM 19 (AND DEPENDENTS)

A. Claims 19 and 20 Are Not Obvious Over the Combination of Parulski, Ogata, Kawamura, and Soga (Ground 1, -00906 IPR)

1. A POSITA Would Not Have Been Motivated to Use the Ogata and Kawamura Lens Designs with Parulski

89. In this ground, Apple and Dr. Durand propose combining Parulski with Soga and with two patents describing lens designs, Ogata and Kawamura. Dr. Moore has provided an extensive discussion of the Kawamura and Ogata lens designs and a response to Dr. Sasián’s opinions concerning scaling these lens designs, which I have reviewed. (Ex. 2015, Moore Decl.) Dr. Moore is an expert in optics and in lens design, and I rely on his analysis in this declaration.

90. Dr. Moore describes the Kawamura lens design at length. (Ex. 2015, Moore Decl., ¶¶ 40–58.) As he explains, Kawamura’s lens was designed in the early 1980s for a larger than 35 mm film camera. The lens examples

provided in Kawamura were over 7 inches long, and a POSITA would recognize that a camera utilizing them would have weighed many pounds. (Id.)

91. Dr. Moore also describes the Ogata lens design at length (Ex. 2015, Moore Decl., ¶¶ 59–67.) This lens was designed in the early 1990s and designed for use in a 35 mm film camera. (Id.)

92. A POSITA in 2007 (when Parulski was filed) or in 2013 would not have been motivated to combine multiple large and heavy lenses designed for film cameras to create an even larger, heavier, and more unwieldy dual-lens camera. Rather, Parulski describes its invention in terms of compact digital point-and-shot cameras and mobile phones:

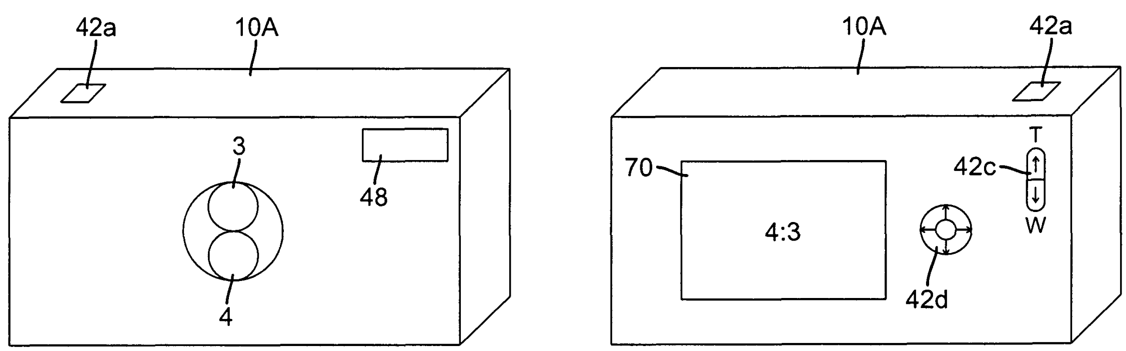


FIG. 2A

FIG. 2B

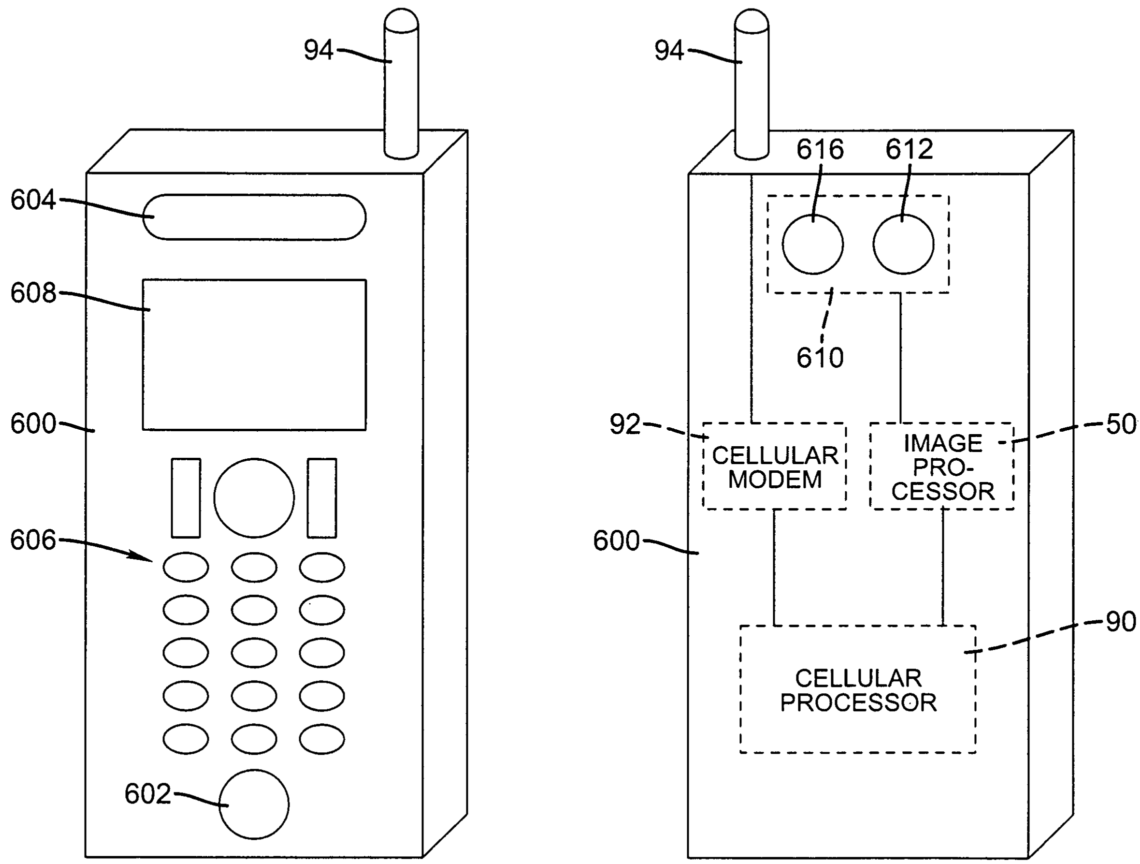


FIG. 15A FIG. 15B

(Ex. 1005, Parulski, Figs. 2, 15.)

93. As a result, the combination that Apple and its expert propose requires scaling the Kawamura and Ogata lens designs down to a size appropriate for a 1/2.5-inch image sensor. (-00906 Petition at 19–20, 26–27; Ex. 1003 in -00906 IPR, Durand Decl., ¶¶ 47–49, 58–60; Ex. 1021, Sasián Decl. at 18, 22.)

94. As explained by Dr. Moore, the lenses in Kawamura and Ogata must be scaled down by a significant factor to reach the size proposed by Apple: a factor of 12.25 for the Kawamura lens (Ex. 2015, Moore Decl, ¶ 50) and a factor of 6.114 for the Ogata lens (id., ¶ 63.)

95. Dr. Moore explains at length the reasons that one skilled in the art in 2007 or later, looking for 1/2.5-inch sensors for a digital system like Parulski would have looked to lenses designed for miniature digital camera modules, not to 15- and 25-year-old lenses, many times larger than desired, designed and built using old technology, intended for use in film cameras. (Ex. 2015, Moore Decl., ¶¶ 68–107.) Dr. Moore further explains reasons that a POSITA would not have expected scaling Kawamura and Ogata to yield successful results. (Id.)

96. Since a POSITA would not have been motivated to use Kawamura and Ogata unmodified with Parulski (and Apple does not even propose doing so), and a POSITA would not have been motivated to scale Kawamura and Ogata as proposed by Apple, a POSITA would not have been motivated to combine Kawamura and Ogata with Parulski (and Soga), and the claims challenged under this ground are not obvious.

2. Apple Has Not Shown that the Limitation "to find translations between matching points in the images to calculate depth information and to create a fused image suited for portrait photos" Is Satisfied Under Its Proper Construction

97. As discussed above, Apple's proposed construction of "to find translations between matching points in the images to calculate depth information and to create a fused image suited for portrait photos" improperly splits the phrase into two, unrelated steps. Dr. Durand's obviousness combination likewise improperly splits related claim limitations into unrelated steps.

98. Dr. Durand calls the phrase "to process the Wide and Tele images to find translations between matching points in the images to calculate depth information" limitation [19.5.1], and calls the phrase "and to create a fused image suited for portrait photos" limitation [19.5.2]. (Ex. 1003 in -00906 IPR, Durand Decl. at 63, 66.)

99. For limitation [19.5.1], Dr. Durand points solely to Figure 11 of Parulski and to Parulski's discussion of that figure. (Ex. 1003 in -00906 IPR, Durand Decl. at 63–66; Ex. 1005, Parulski at 19:49–20:15. Fig. 11).

100. For limitation [19.5.2], Dr. Durand points to a portion of Parulski's discussion of Figure 14. (Ex. 1003 in -00906 IPR, Durand Decl. at 66;

Ex. 1005, Parulski at 22:14–42.) However, he concedes Parulski does not disclose limitation [19.5.2] (or limitation [19.5.3]), because creating "a fused image suited for portrait photos" (and with a shallower DOF) in the context of Parulski requiring narrowing the depth of field of the original images, but the teachings in Parulski that Dr. Durand points to only discuss *broadening* (i.e., "enhancing") the depth of field. (Ex. 1003 in -00906 IPR, Durand Decl. at 66; Ex. 1005, Parulski at 22:14–42.)

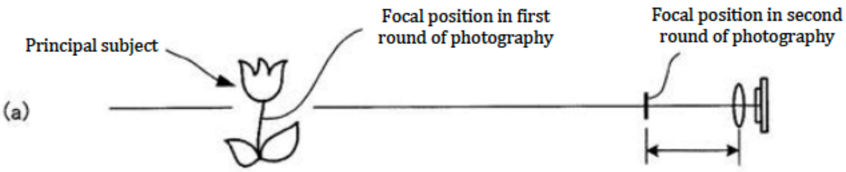
101. Because Parulski does not disclose narrowing the DOF, Dr. Durand points to Soga to satisfy the limitation "and to create a fused image suited for portrait photos." (Ex. 1003 in -00906 IPR, Durand Decl. at 66–69.) However, Soga does not satisfy the broader term "to process the Wide and Tele images to find translations between matching points in the images to calculate depth information and to create a fused image suited for portrait photos," under the correct interpretation of that term.

102. Soga does not utilize depth information or matching of points in the image at all. Indeed, it performs image segmentation solely based upon the first image.

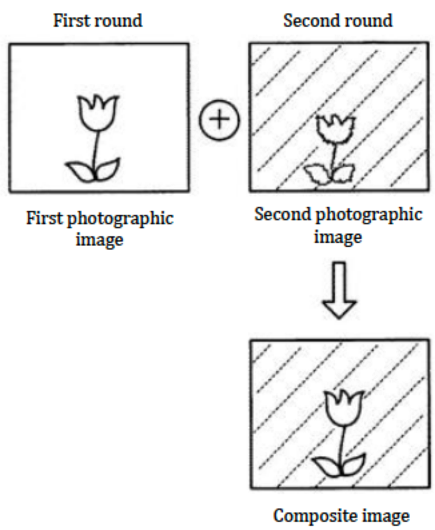
103. Soga captures two images with a same camera, as shown in Figure 4:

[FIG. 4]

(a)



(b)



(Ex. 1006, Soga, Fig. 4.)

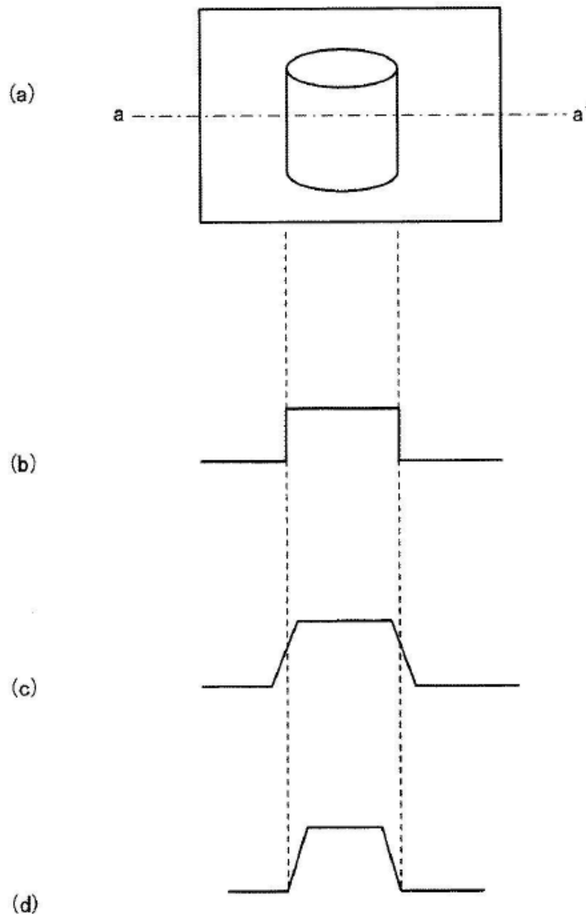
104. As shown in this figure, the first photograph is focused at the position of the principal subject, so that the details of that subject (e.g., the flower) will be sharp. (Id., ¶¶ 65–66.) The second photograph is focused at a much shorter distance, such that both the principal subject and the background

are out of focus (illustrated by the wavy outline of the flower in the second image). (Id.)

105. The images are combined by "cutting" the principal subject out of the first image and inserting it into the second image. (Ex. 1006, Soga, ¶¶ 54, 56.) But, this cutting step is performed before the second image has even been captured. Specifically, the first image is captured and stored in memory (id., ¶ 52), then the camera is adjusted to take the second image (id., ¶ 53), then while the second image is being captured, the circuitry performs "edge detection" on the first image and "cuts out the principal subject" (id., ¶ 54), and after that is complete, the second image capture is completed (id., ¶ 55).

106. There is a good reason that Soga only uses the first image in order to identify what region to cut out for the principal subject. Soga utilizes an edge detection technique illustrated in Figure 3:

[FIG. 3]



(Ex. 1006, Soga, Fig. 3.)

107. Successful edge detection depends on a sharp change in the image at the edge of the object—what Soga refers to as a "high frequency component" in the signal. (Ex. 1006, Soga, ¶¶ 59–61.) In the second (out of focus) image, the high frequency components are substantially reduced, and the sharp edge is gone. (Id., ¶ 61.) The blurry second image does not have useful

information for determining where to cut the first image. It also could not be used to produce depth information, because it was captured using the same camera at the same location as the first image, and no parallax between the cameras is present.

108. Because Soga relies solely on the information in the first image to identify the principal subject, and because it simply pastes the cutout principal subject into the second image without modification, it does not utilize "translations between matching points in the images" as part of creating the fused image. Indeed, Dr. Durand points to Soga's not needing "an accurate depth map" as a benefit of Soga that he believes would have motivated a POSITA to combine it with Parulski. (Ex. 1003 for -00906 IPR, Durand Decl., ¶ 76.) Based on Dr. Durand's arguments for combination in ¶ 76, the art (including Soga and Jacobs) teach away from modifying Soga to make use of "translations between matching points in the images" or "depth information." (Id., ¶ 76; Ex. 1007, Jacobs at 2.)

109. As a result, the combination of Parulski and Soga only satisfy the limitations of claim 1(e) under an interpretation that improperly treats "to create a fused image" as a completely separate step that does not in any way

relate to or depend on the "to find translations between matching points" limitation.

B. Claims 21 and 22 Are Not Obvious Over the Combination of Parulski, Ogata, Kawamura, Soga, and Morgan-Mar (Ground 2, -00906 IPR)

110. Claim 21 depends from 20, and claim 22 depends from 21. (Ex. 1001, '479 patent at 15:43–49.) For both claims, Apple relies on the Ground 1 combination to satisfy the elements that these claims inherit from claims 19 and 20. As a result, the same analysis provided above for claims 19 and 20 applies to this ground, and Apple has not shown claims 21 and 22 to be obvious, either.

111. I also disagree that one skilled in the art would have been motivated to combine Morgan-Mar with the other four references making up this ground. Morgan-Mar, titled "Bokeh Amplification" discloses methods designed for an ordinary single-lens image capture device. Morgan-Mar teaches a preference for determining depth from multiple images taken from the same POV (allowing only for slight camera movement) at different times, by examining the degree of blur of pixels corresponding to out-of-focus points in the scene.

112. Morgan-Mar at Fig. 5 illustrates an example where multiple images are used. These images are intended to be captured from a single POV (camera position and orientation) using different camera parameters (e.g. focus settings). Mogan-Mar does not rely on any shift in the POV of the captured images, but can accommodate "slight camera movement between capture of the two images" (Ex. 1009, Morgan-Mar at 19:33-34). Fig. 6 further illustrates that Morgan-Mar depends on an alignment between pixels in patches in the first image and corresponding pixels in patches in a second image, as explained by Morgan-Mar at 19:55-20-21:39. "Many such alignment processes are known to those skilled in the art" (id. at 10:10-11) but would need to be robust enough to "address issues such as motion of the object such as motion of objects within the scene between the two exposures, motion of the camera 427 between the two exposures, and changes in the magnification or distortion or both between the two exposures" (id. 20:4-8).

113. Dr. Durand opines at ¶ 87 that a POSITA would have been motivated to combine Morgan-Mar with Parulski and Soga. (Ex. 1003, Durand Decl., ¶ 87.) I disagree. While Morgan-Mar and Parulski are both directed at manipulating depth-of-field effects in photographs, they approach the prob-

lem from incompatible directions. Parulski relies on multiple images but captured simultaneously from separate imaging sections with separate POV's, whereas Morgan-Mar expects multiple images from the same imaging section and a single POV (or with "slight movement") but taken at different times. Parulski's determination of depth depends critically on the reliance that the multiple images have a different POV enabling stereo correspondence. Parulski's stereo correspondence is a simpler and more robust global process for determining pixel offsets than Morgan-Mar's more general patch-based process needed to handle the registration of multiple temporally distinct images that could include articulated motion in different directions in the scene between images in the collection of multiple images used. A POSITA would not have looked to the significant additional processing burden needed for constructing a range map when a more robust dual lens stereo correspondence was already available in Parulski.

XI. [redacted] / OBJECTIVE INDICIA OF NON-OBVIOUSNESS

114. In my understanding, when considering the question of whether the claims of an issued patent are not obvious, there are numerous examples of objective evidence (sometimes called "secondary considerations" or "ob-

jective indicia") of non-obviousness. As I explained above, it is my understanding that I should consider any objective evidence that may have existed at the time of the invention covered by an issued claim and which may shed light on the obviousness of the claims, such as:

a. Whether the invention was commercially successful as a result of the merits of the claimed invention (rather than the result of design needs or market-pressure advertising or similar activities);
b. Whether the invention satisfied a long-felt need;
c. Whether others had tried and failed to make the invention;
d. Whether others invented the invention at roughly the same time;
e. Whether others copied the invention;
f. Whether there were changes or related technologies or market needs contemporaneous with the invention;
g. Whether the invention achieved unexpected results;
h. Whether others in the field praised the invention;

i. Whether persons having ordinary skill in the art of the invention expressed surprise or disbelief regarding the invention;

j. Whether others sought or obtained rights to the patent from the patent holder; and

k. Whether the inventor proceeded contrary to accepted wisdom in the field.

115. It is also my understanding that such secondary considerations must have a nexus to the claimed invention to be relevant to the issue of obviousness.

116. Based on the materials that I have reviewed and my knowledge and experience, it is my opinion that there are several secondary considerations of non-obviousness that support my conclusion that Petitioner has not sufficiently demonstrated the challenged claims are obvious in view of the prior art references identified by Petitioner. These secondary considerations include at least industry praise, licensing, commercial success, and failure of others / copying.

117. First, I understand that Patent Owner has, in response to petitions for *inter partes* review filed by Petitioner in IPR2020-00860 and IPR2020-

00487, filed declarations signed by Eli Saber, Ph.D., in which Dr. Saber describes evidence relevant to secondary considerations non-obviousness of the patents challenged in those *inter partes* review proceedings. I have been reviewed the portions of Dr. Saber's declarations, which is filed as Exhibit 2015 in IPR2020-00860 and IPR2020-00487. Dr. Saber's declarations address and describe some of the same evidence that I reviewed in performing my analysis on secondary considerations in these proceedings, and in some instances I have adopted and used Dr. Saber's language and descriptions of the secondary considerations-related evidence for consistency.

118. Second, I note that the Petition, Dr. Durand's declaration (Ex. 1003), and Dr. Saisian's (Ex. 1021) declaration are silent as to whether there is evidence of secondary considerations of non-obviousness as to the challenged claims. To the extent Petitioner presents arguments regarding secondary considerations in the future, I reserve the right to supplement my testimony to provide opinions in response, as appropriate

119. Third, the critical aspects of the '479 patent can be divided into two categories: first, (1) a dual aperture camera design with Corephotonics' inventive telephoto lens; and second, the (2) use of image fusion techniques to output a fused image using images from both Wide and Tele cameras. For

example, the '479 patent provides an embodiment of a "dual-aperture zoom imaging system" which includes a "Wide imaging section" and a "Tele imaging section." *See* Ex. 1001, at 4:29-52. For example, the Tele lens "has a respective effective focal length EFLT and total track length TTL_T fulfilling the condition $EFL_T/TTL_T>1$." *Id.*, at cl. 1. The '479 patent also describes the use of "a camera fusion processing core" which, performs an algorithm which results in a "fusion step" where "re-sampled Tele image and the Wide image are fused into a single zoom image." *See id.*, at 9:39-60.

120. I have considered whether there is a "nexus" in the secondary considerations to this aspect of the invention of the '479 patent in my analysis. Thus, for example, if there is evidence of industry praise (from Petitioner or a third party) relating to Corephotonics's fusion algorithms or dual-camera design, I see that as evidence of a "nexus" between that industry praise and the invention of the '479 patent.

A. Industry Praise / Licensing

121. Industry praise and licensing support non-obviousness. In that regard, I note that Petitioner and Patent Owner had extensive and detailed discussions regarding Petitioner's use of Patent Owner's technology. I note that Patent Owner's public complaint, in *Corephotonics, Ltd. v. Apple Inc.*, Case

No. 6:19-cv-04809-LHK (Dkt. No. 1) (Ex. 2004) ("Complaint"), provides a great amount of detail regarding those discussions, which lasted from 2012 to 2017. *See* Ex. 2004, at ¶¶ 28-44. I have also read Petitioner's "Answer" to Patent Owner's public complaint, which in relevant part "admits" that "Apple personnel attended meetings with Corephotonics personnel to discuss a potential business arrangement." *See, e.g.*, Ex. 2005 at ¶¶ 28-44.

122. I have analyzed whether the allegations in Patent Owner's public complaint concerning Petitioner's attempt to license Patent Owner's technology are supported by evidence and whether there is a nexus between those licensing discussions with the invention of the '479 patent. The answer is "yes" to both questions.

123. To determine whether Patent Owner's allegations in its complaint are supported by evidence, I reviewed emails and documents dating from 2012 through 2017, as well as the Declaration of Eran Kali ("Kali Decl." or "Kali Declaration") (Ex. 2013) which describes Corephotonics's business, its licensing history, the relevant facts as to the technology licensing discussions between Patent Owner and Petitioner, and several documents that corroborate the allegations in Patent Owner's Complaint. I have attached a small selection of those communications and documents for exemplary purposes

and describe them below. As I have demonstrated below, the documentary evidence generally confirm the accuracy of the allegations that Patent Owner has provided in its public complaint:

- [redacted]
- [redacted]
- [redacted]

- [redacted]
- [redacted]
- [redacted]
- [redacted]

- [redacted]
- [redacted]
- [redacted]

124. As the evidence shows, the licensing discussions between Petitioner and Patent Owner lasted over many years. Petitioner specifically asked Patent Owner [redacted] Apple specifically asked for, and received, technological samples of

Corephotonics' lens designs and Corephotonics' image fusion algorithms. *See* Exs. 2007, 2011, 2012, 2018, 2019, 2020, 2021, 2022, Kali Decl., at ¶¶ 17-30. The licensing discussions specifically would have encompassed the lens design and image fusion technology that Patent Owner had provided, on a confidential and NDA basis, to Apple years earlier. It specifically would have also encompassed a license to Corephotonics's U.S. Patent No. 9,185,291 (the "'291 patent"), to which the '479 patent claims priority. This is evidence that there is a "nexus" between the licensing negotiations between Patent Owner and Petitioner as the claims of the '479 patent challenged by Petitioner in this proceeding. Petitioner's years-long effort in studying Patent Owner's patented technology (and specifically the technology at issue in the '479 patent), combined with the Petitioner's [redacted] demonstrates Petitioner's respect for Patent Owner's technology and the non-obviousness of the challenged claims.

125. Like Apple, numerous other technology companies have recognized the value in Patent Owner's camera and image processing technology and taken licenses to Patent Owner's patented technology. These companies

include, OPPO Mobile Telecommunications[6], one of the top 5 global smartphone vendors, and Samsung Electro-Mechanics[7]. Other companies who have taken licenses to Corephotonics's technology include [redacted] *See* Kali Declaration, ¶¶ 11-16. The fact that several companies have taken licenses to Corephotonics' technology is evidence of industry-wide respect for the patented technology.

126. Corephotonics has been described as a "leader in multi-camera technology,"[8] "a world-renowned leader in the mobile imaging space,"[9] "a leading supplie[r],"[10] and a "key player" in the computational photography

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[6] https://corephotonics.com/press-releases/oppo-signs-strategic-license-with-corephotonics-for-next-generation-mobile-handset-cameras/

[7] https://corephotonics.com/press-releases/corephotonics-collaborates-samsung-electro-mechanics-bring-new-era-imaging-smartphones/

[8] https://twitter.com/UniverseIce/status/1169611027266203648. I understand "Ice Universe" is recognized as one of the leading industry observers in the Android space (and, more specifically, Samsung phones) and is known for publishing confidential industry information. *See, e.g., http://www.businesskorea.co.kr/news/articleView.html?idxno=59259* ("Ice Universe, a famous twitterian in the global IT industry").

[9] https://optics.org/news/8/1/21.

[10] https://www.photonics.com/Articles/OPPO_to_Collaborate_with_Corephotonics/a63427.

market[11]. As early as 2015, Corephotonics had already been recognized as the industry leader in developing dual-camera designs and software technologies to power them, with industry observers speculating: "All this raises the question of whether Apple will use a Corephotonics module."[12] Widespread praise of Corephotonics's technologies is yet further evidence of non-obviousness.

127. Another fact that demonstrates Petitioner's respect for the technology in the '479 patent is Petitioner's repeated and numerous citations to the '291 patent. The '291 patent, which establishes the priority date for the '479 patent, is cited on the face of numerous patents assigned to Petitioner, such as U.S. Patent Nos. 9,769,389; 9,774,787; 9,781,345; 10,063,783; 10,122,931; 10,136,048; and 10,264,188.

B. Commercial Success

128. In my opinion, commercial success attributable to the invention of the '479 patent supports non-obviousness of the challenged claims. In 2019,

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[11] https://reportedtimes.com/computational-photography-market-to-develop-new-growth-story-emerging-segments-is-the-key/.

[12] https://www.forbes.com/sites/gordonkelly/2015/01/14/iphone-6s-dual-lens-camera-optical-zoom/?sh=4936af1216c6.

Patent Owner was acquired by Samsung Electronics Benelux BV for a reported $155m. *See* Kali Decl. ¶ 16. Samsung's acquisition of Patent Owner was widely reported in industry news, e.g.:

- Paul Monckton, "Samsung Buys Significant New Camera Advantage Over Apple," Forbes.com (Jan. 29, 2019), https://www.forbes.com/sites/paulmonckton/2019/01/29/samsung-corephotonics/?sh=2c6c144b2de7 (accessed Jan. 25, 2021)

- Omri Zerachovitz, "Samsung buys Israeli co Corephotonics for $155m," Globes.com (Jan. 28, 2019), https://en.globes.co.il/en/article-samsung-buys-israeli-co-corephotonics-for-155m-1001270699 (accessed Jan. 25, 2021)

- Jon Fingas, "Samsung reportedly bought a company to improve its phone cameras," Engadget (Jan. 29, 2019), https://www.engadget.com/2019-01-29-samsung-reportedly-buys-corephotonics.html (accessed Jan. 25, 2021)

129. Patent Owner's acquisition by Samsung, one of the world's leading smartphone manufacturers, is evidence of Patent Owner's commercial access and is attributable to Patent Owner's innovative technology, including its smooth transition algorithms. It is thus evidence tending to support the non-obviousness of the challenged claims.

C. Failure of Others / Copying

130. In my opinion, the failure of others, including Petitioner, to successfully address the problems stated in the ’479 patent using position matching and image registration to reduce the image jump effect is evidence of the non-obviousness of the challenged claims. The evidence of Apple’s copying of the ’479 patent’s technologies from Patent Owner also supports my conclusion.

131. I understand that the failure of others, including the Petitioner, to solve the problems addressed in the ’479 patent in the manner claimed by the ’479 patent is evidence that suggests that the ’942 patent’s claims are non-obviousness. *See Heidelberger Druckmaschinen AG v. Hantscho Commercial Products, Inc*., 21 F.3d 1068, 1072, 30 U.S.P.Q.2d 1377 (Fed. Cir. 1994) (the “argument that an innovation is really quite ordinary carries diminished weight when offered by those who had tried and failed to solve the same problem, and then promptly adopted the solution that they are now denigrating.”).

132. To begin, none of Petitioner’s prior art discloses the entirety of the central innovation of the ’479 patent: a dual-aperture camera system with logic for fusing image data from two cameras.

133. Petitioner's own long-standing failure to successfully write image fusion algorithms or design an effective long focal length telephoto lens design (such as the one Corephotonics provided to Apple) for its own iPhone projects using the technologies claimed in the '479 patent until 2016, by which point Petitioner had had years of analysis, access, and experience with Patent Owner's patented lens designs and image processing techniques, is further evidence of non-obviousness. Petitioner's copying of Patent Owner's technologies, including image fusion techniques that Patent Owner demonstrated to Petitioner and the telephoto lens designs it provided to Petitioner, is evidence of non-obviousness. That Petitioner copied the invention of the '479 patent (among other Corephotonics technologies, which Petitioner also appears to have copied) is strongly implied by the course of conduct between the parties and the timing of Petitioner's announcement of their dual-aperture camera in their iPhone 7 series in Fall of 2016. In that generation, Apple introduced its still-image fusion feature for the first time. *See, e.g.*, "What's new in Camera Capture on iPhone 7 and iPhone 7 Plus," https://forums.developer.apple.com/thread/63347 (Authored by "Apple Staff"): "When zoomed, the Dual camera intelligently fuses images from the wide-angle and telephoto cameras to improve image quality. This process is transparent to the user and happens

automatically when you take pictures using AVCapturePhotoOutput or AVCaptureStillImageOutput."

134. Numerous of Petitioner's own camera and image processing patents cite the '291 patent (to which the '479 patent claims priority), as I have previously explained. This suggests Apple has built its own camera and image processing technology based on the technology at issue in the '479 patent. All of these facts support, in my view, a conclusion that the challenged claims are not obvious.

XII. DECLARATION

135. I declare that all statements made herein of my own knowledge are true, that all statements made on information and belief are believed to be true, and that these statements were made with knowledge that willful false statements so made are punishable by fine or imprisonment, or both, under section 1001 of Title 18 of the United States Code.

Executed on February 4, 2021

John C. Hart, Ph.D.